

EFFECTS OF PHYSICAL AND BIOLOGICAL FACTORS ON AGGREGATE DYNAMICS IN SITU
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INTRODUCTION

Much of the marine snow in the ocean is formed by the collision and subsequent sticking of smaller particles present in the water column. The rate at which these smaller particles coagulate in nature depends directly upon 3 factors: 1) the abundance of component particles available for collision (primarily a function of biological processes), 2) the collision frequency of these particles (primarily a function of turbulent shear), and 3) the efficiency with which the particles stick once collided.

OBJECTIVES

The research conducted under this grant investigates the effect of the first two factors on aggregate dynamics in situ. We are testing the following hypotheses:

Hypothesis 1: The abundance of marine snow in the surface ocean is primarily a function of the abundance of component particles available for aggregation. Aggregation abundance is thus directly correlated with the magnitude of biological activity. JTK

Hypothesis 2: The size distribution of marine snow in the ocean is primarily a function of turbulent shear stresses. Increased turbulence also results in increased aggregate abundance other conditions being equal.

TECHNICAL APPROACH

Our approach in investigating the above hypotheses is to determine the abundance and size distribution of marine snow in surface waters off southern California as a function of vertical and horizontal variations in biological activity (surface production, Chl. a, smaller particle abundance, zooplankton grazing), temperature, salinity, and water column turbulent microstructure. The research is being conducted in two stages. During Stage 1 (year 1) the relationship between marine snow abundance and size distribution and vertical variability in biological and physical parameters of the water column has been investigated. During Stage 2 (year 2) Stage 1 activities will be continued and investigations of marine snow distribution and formation as a function of turbulent microstructure will begin. TR

DISTRIBUTION STATEMENT A

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ACCOMPLISHMENTS DURING YEAR 1 (JULY 1, 1989 - SETEMBER 30, 1990)

1. Manuscripts

The following manuscripts based on previous ONR research were written and accepted for publication:

Allredge, A.L., T.C. Granata, C.C. Gotschalk and T. D. Dickey (1990)
The physical strength of marine snow and its implications for
particle disaggregation in the ocean. Limnology and Oceanography
(IN PRESS).

Allredge, A.L. and P. McGillivray (1991) The attachment probabilities
of marine snow and their implications for aggregation processes in
the ocean. Deep-Sea Research (IN PRESS).

2. Microstructure Profiler

The Microstructure Profiler required for testing of hypothesis II
during Year 2 was ordered from Dr. Jorg Imberger's research group at the
Center for Water Research, University of Western Australia, and
delivered in May, 1990.

We have accomplished the following in preparation for its use:

- a. Completed a laboratory test of the instruments' capabilities
- b. Completed a successful field test of the instrument
- c. Purchased a Sparks (Sun) computer workstation for data analysis
- d. Completed program modifications to software provided by Imberger
so that the profiler data can be analyzed on our systems. This
was a nontrivial exercise since the profiler is expected to
generate about 8 gigabytes of data per year.
- e. Completed a successful test of software which downloads data
from the hard disk in the profiler to the computer
- f. Completed a successful test of computer analysis of profiler
data

We are presently working on:

- a. Establishment of a calibration facility in the lab for routine
periodic calibration of the profiler
- b. Development of appropriate software for plotting the
microstructure profiles generated

Considering the complex nature of the data acquisition and analysis
with this instrument we feel that we have made excellent progress in the
first year.

3. IN SITU Marine Snow Camera System

We have completed the Marine Snow Camera System. The video portion
of this system was completed during 1988-89. We now have a completed
instrument package which collects the data simultaneously with depth.
It has the following capabilities:

- particle size distribution (video and still camera systems)
- temperature - Seabird CTD
- salinity - Seabird CTD

depth - Seabird CTD and both camera systems
qualitative small particle abundance - transmissometer
fluorescence - Seacat fluorometer

The following was accomplished during the past year:

a. Completion of the image analysis program for analysis of video output. This program gives us mean and standard deviation values for aggregate volume, equivalent spherical diameter, and maximum diameter at 1 meter intervals with depth. It also gives us a particle size distribution histograms for aggregate volume, equivalent spherical diameter and maximum length at 2 m intervals to 200m.

b. Completion of the still camera system based on the Honjo et al. (1984) design. This system allows us to collect data on snow abundance during the day (the video system must be operated at night) and will allow quantification of very small particles, down to about 50 μm . In tandem the still and video cameras provide quantitative information on the full spectrum of particle sizes from 50 μm to 25 cm in size.

c. Completed a successful field test of the still camera system

4. Investigations of Hypothesis I

During April, 1990, we conducted extensive ONR research while piggybacking aboard a cruise of the R/V Point Sur sponsored by Alldredge's NSF grant. During this cruise we investigated the correlations between aggregate abundance, size distribution and water column parameters with depth using the Marine Snow Camera package (without the still camera). We collected 20 profiles of marine snow abundance as a function of water column parameters including fluorescence, temperature, salinity, transmission and surface productivity. We also tested the repeatability of the camera system by taking replicate profiles while following a drogue. We are presently analyzing these profiles and Dr. Alldredge will be spending the late fall writing a paper on our results. We have found a very strong correlation between stratification and marine snow abundance which has been largely missed by previous still camera systems (Honjo, Asper, Gardner) primarily because these systems are designed to go to great depth and have not been deployed in such a manner as to obtain high resolution in the mixed layer. Maximum particle sizes and volumes almost always occurred in the thermocline. Marine snow abundance appears to be lower at the Chl. max. (Fig. 1).

RESEARCH PLANNED FOR YEAR 2

During Year 2 we plan to conduct studies on the following:

a. Turbulent mixing and snow production

We will follow a parcel of water with a drogue before, during and after a strong, daily mixing event. Our plan is to obtain profiles of snow abundance and microstructure profiles during a calm morning and then follow changes in the particle size distribution as strong afternoon winds are generated. This will allow us to see immediate effects of increased mixing and turbulence on collision frequencies and marine snow production.

b. As a control on coagulation processes we will investigate zooplankton feeding as a mechanisms controlling particle size distributions. We will follow a parcel of water over 24 hours periods, obtaining profiles of marine snow abundance and vertical distributions of zooplankton at 10 meter intervals to 50 meters at 6 hour intervals. By observing changes in the abundance and size distribution of aggregates as animals migrate into surface waters at night, we will be able to obtain estimates of the importance of feeding as a confounding factor for coagulation studies.

c. We will continue our investigations of both Hypothesis I and II during a spring cruise in 1991. This cruise is funded by NSF to follow a diatom bloom through the flocculation event. The NSF research will investigate silica cycling, particulate flux and changes in diatom physiology over time. Thus it complements perfectly the ONR research on coagulation and will, hopefully, provide some preliminary data to assist in the SIGMA field program.



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Figure 1A: Temperature, Chl. a and the abundance of marine snow aggregates larger than 0.4 mm in diameter at 33° 48'N, 120° 8"N (Santa Barbara Channel), on April 18, 1990, as a function of depth. Note that maximum aggregate abundances occur at the top of the thermocline and above the Chl. max.

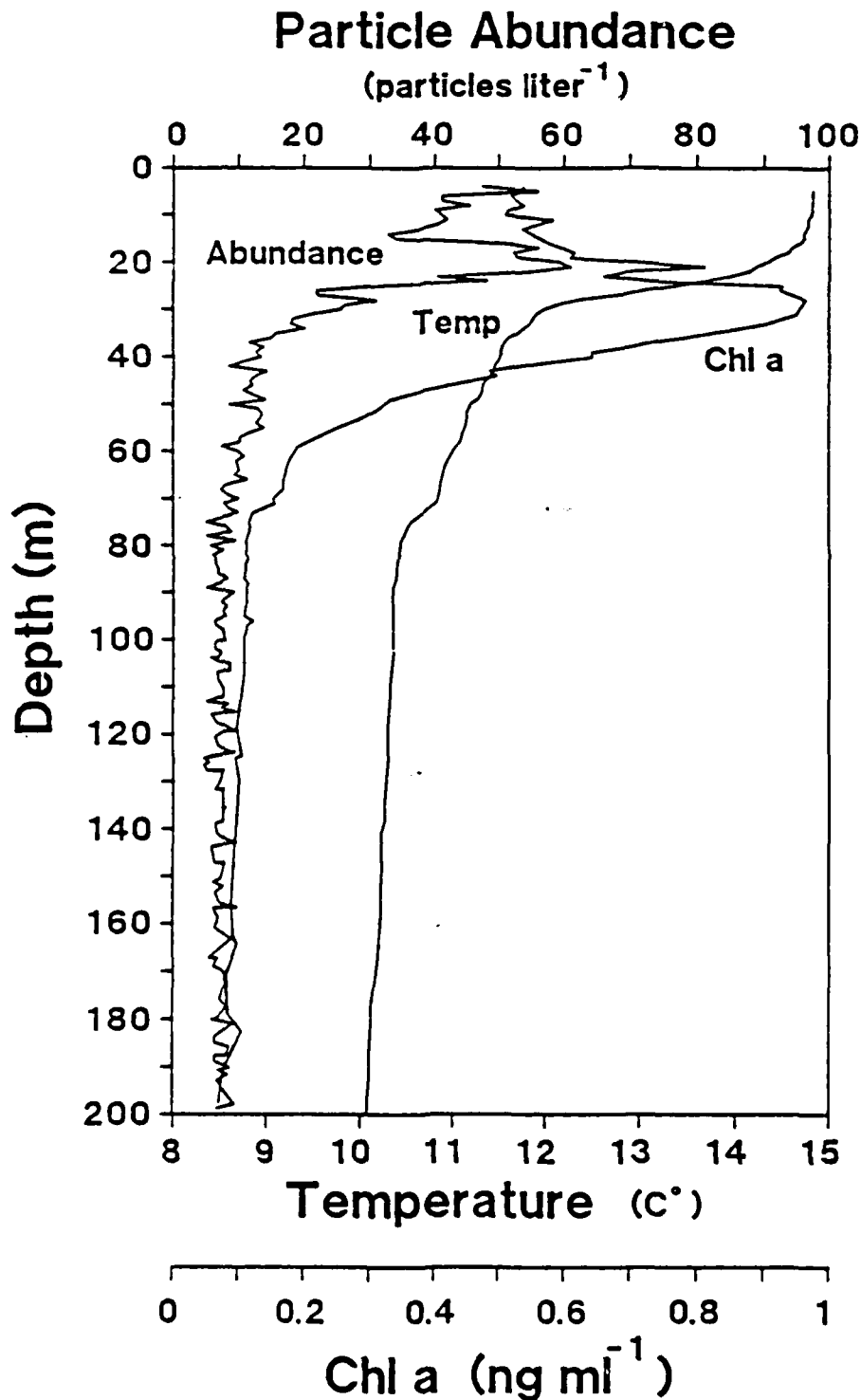


Figure 1B: Size frequency distributions with depth of the aggregates in Fig. 1A. Note that the highest abundance of large particles, those with maximum diameters from 4 to 8 mm also occur right at the top of the thermocline at about 20 m.

